ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5347

Acidified feed (silage) for fish
Practical experiences

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Original title: Surfôr til fisk -- erfaringar og praktisk bruk

In: (Unknown)

Original language: Norwegian

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1988

11 typescript pages

90-01482/l

Secretary of State / Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU BUREAU DES TRADUCTIONS

LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

Translated from - Traduction de	Into - En
NORWEGIAN	ENGLISH

Author - Auteur

ERLAND AUSTRENG

Title in English or French - Titre anglais ou français

ACIDIFIED FEED (SILAGE) FOR FISH - PRACTICAL EXPERIENCES

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)

SURFÔR TIL FISK - ERFARINGAR OG PRAKTISK BRUK

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.

N.A.

Reference in English or French - Référence en anglais ou français

N.A.

Publisher - Éditeur	DATE OF PUBLICATION / DATE DE PUBLICATION			Page Numbers in original / Numéros des pages dans l'original
N.A.	Year / Année	Volume	Issue No. / Numéro	6
Place of Publication / Lieu de publication				Number of typed pages / Nombre de pages dactylographiées
NORWAY				8

Requesting Department / Ministère-Client: DFO

Translation Bureau No. / Notre dossier nº: LSM-7-706

Branch or Division / Direction ou Division: IPB

Translator (Initials) / Traducteur (Initiales): SOWF

Person requesting / Demandé par: NANCY JOHNSON

Your Number / Votre dossier nº: 3287254

DEC 22 1987

Date of Request / Date de la demande: 87-11-10

Canada

SEC 5-111 (84-10)

Department of the Secretary of State of Canada | Secrétariat d'État du Canada

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU | BUREAU DES TRADUCTIONS

Client's No.–N° du client	Department – Ministère	Division/Branch – Division/Direction	City – Ville
3287254	DFO	IPB	OTTAWA
Bureau No.–N° du bureau	**Language – Langue**	**Translator (Initials) – Traducteur (Initiales)**	
LSM-7-706	NORWEGIAN	SOWF	DEC 22 1987

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by

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Institute for Poultry and Fur Animals,
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Much of the available fish raw material is not put to practical use in Norway. To the extent that one can locate this raw material, it would seem logical to use more of this raw material for fish feed. However, fluctuations in availability makes it essential to store most of this raw material for shorter or longer periods. Although cold storage is a good method, it is often costly and work-intensive. To provide an alternative method, we have at the Research Station for Salmon been working with acidified fish feed since 1977. This is of course not a new idea. We only picked up the thread from the 1940's when the Institute for Poultry and Fur Animals was working on acidified feed for other animals.

When we began our test a number of questions arose. Which acids would provide satisfactory preservation? Will the fish accept acidified feed? Will the fish experience negative effects from the feed? Will the acidified feed influence the fish quality? What should be done to provide the right consistency of the feed? What raw materials are suitable for this type of preservation?

We have gradually developed the answers to many of these questions, but some work remains to be done with regard to the final question.

Storage

During our storage tests, some 50 acid compounds were tested (Austreng et al 1979, Austreng 1980). The results show that the smallest additions of organic acids which provide satisfactory storage are 2.2% formic acid (M), 2.2% propionic acid (P) or 1.1% M + 1.1% P. With sulphuric acid (S) some 2.5% are required together with a little formic acid, propionic acid or acetic acid. The samples were stored for approximately one year.

The amount of acid required varies slightly depending on the type of waste used. If there are many bones in the mixture, more acid is required to make the mixture acid enough to prevent bacteria and fungi from ruining the acid feed (pH 4-4.5 in finished, stable acidified feed). If the fat content is high in the waste, it may also be appropriate to add an antioxidant (ethoxyquin - 0.01%) to prevent the fat from turning rancid.

Formic acid is more easily available than sulphuric acid, and formic acid is also less dangerous to handle. However, with regard to price, the sulphuric acid is more reasonable. The difference in cost amounts to a few ore per kg finished acidified feed, but this should amount to less than 15 ore per kg.

Feed consistency

Tests were carried out in 1977 to establish how fish react to acidified feeds (Austreng 1980). These feeds were very acid (pH 2.7-3.6). Nonetheless, both the rainbow trout and the salmon grew adequately on this feed. However, they grew less than the fish that were fed frozen feed. Digestive processes in the acidified feed quickly lead to a soup-like consistency. In this test, a binding agent was added to an amount of 10%; however, the final consistency was very loose and it was difficult to distribute the feed.

To correct this loose consistency, an appropriate binding agent was developed. It comprised 47% herring meal, plus 47% halibut paste, plus 4.5% alginate, plus 1.5% vitamin mix. This provided a good mix consistency with a 35-50% admixture. The admixture % will vary according to the structure of the acidified feed. We expect that feed producers gradually will establish other and better binding agents.

Raw material quality

A growth test was carried out in 1978 (Austreng 1980). The feed fish used in the acidified feed was unfortunately of very poor quality, and some batches of acidified feed rotted. Nonetheless, the results were promising for rainbow trout; however, they were disappointing with regard to salmon.

In order to ensure good quality in acidified feed, the raw material must be of good quality whether it concerns feed fish, heads, intestines, filet cut-offs or other waste. Preservation will not improve the quality but it is a method to maintain the quality for a longer period of time.

If there is to be a future for acidified feed, we must ensure that the feed fish is preserved immediately upon catching. Waste from consumer fish can be preserved simultaneously with the processing of the fish. This will ensure high hygienic quality and high nutritional value in the acidified feed.

Growth and product quality

In 1979 five acidified feed mixes which had been well preserved were compared, with regard to growth, with frozen feed (table 1). The feed fish was a trawler fish mix with high fat content.

Table 1. Growth of fish from 29.6.79 to 30.10.79 during a test of various methods of acidification.

Preservation	pH, end	Growth in gram/fish Salmon	Rainbow trout
1. 2.2% M	4.4	580	930
2. 1.1% M + 1.1% P	4.8	-150	925
3. 2.5% S + 1.1% M	3.9	485	840
4. 2.5% S + 1.1% P	4.1	- 65	710
5. 2.5% S + 1.1% E	4.2	270	830
6. Frozen storage		380	975

The rainbow trout showed good growth for all the feed types with the exception of one feed preserved with 2.5% sulphuric acid (S) + 1.1% propionic acid (P). The salmon showed good growth for some of the acidified feed. One feed with 2.2% formic acid (M) and one with 2.5% S + 1.1% M resulted in very good growth, while the feeds with propionic acid showed a weight loss. The feed with 2.5% S + 1.1% acetic acid (E) also showed good growth.

An initial veterinary analysis showed changes in the liver with infected tissue in the bile ducts of the fish which had received acidified feed.

Similar changes were also later found in fish which had been given frozen feed, and these changes could therefore not be related to the acidified feed. The changes were generally moderate.

In this test, as well as in all other tests, fish were sampled for chemical analyses and tasting. No difference between the types of feed could be perceived. Generally none of the tests we have conducted have shown a change in product quality related to the acidified feed.

Overall it can be stated that the results from this test were promising. Formic acid alone or mixed with sulphuric acid provided the best results.

Appetite tests

Several attempts were made to record appetite. No difference could be discerned with regard to rainbow trout. The same result was recorded for salmon during an initial period (1 week); however, later the salmon refused feed with propionic acid.

Long-term effects of acidified feed

A long-term test was begun in 1980 in co-operation with the Svanoy Foundation. Two types of acidified mackerel waste were compared with frozen feed (55% mackerel waste + 45% binding agent). The acids used were 2.5% M and 2.5 S + 0.5% M. The test involved the usual production yardsticks for both salmon and rainbow trout. It began during the autumn after the fish had been placed in the sea when the feed was changed from dry feed to wet feed. The test was carried until slaughter. When the weight of the fish was checked, only very small differences were noted with regard to salmon. However, rainbow trout showed a 10% advantage for the fish which had been given the control feed (the frozen feed). One factor which may have influenced negatively the quality of the acidified feed was that the mackerel waste had been frozen beforehand. Other tests have shown that a trawler fish mixture is more difficult to acidify when the mixture is frozen five days before acidification (Austreng et al.1979). However, the acidified feed had no negative effect on the health of the fish. The consistency of the soft feed was better when acidified feed was used than if frozen feed was used. This strongly influenced the feed losses in that some 30% more feed was required when there were frozen components in the feed.

Raw material for preservation

The raw materials used in these tests with acidified feeds comprised trawler fish of various species. This provided reasonable results. One may therefore assume that fish waste should produce the same results. If there are many bones in the raw material, it is essential that slightly more acid is used to ensure sufficient acidity. However, in all other regards fish waste should function just as well as whole fish. Although we have no test results to support this opinion, practical usage at our own research facility indicates that acidified feed from fish waste will provide good results over a number of years.

Waste from spiny dogfish is slightly different from normal fish waste and constitutes a problem for the fish processing industry. It spoils easily and is difficult to handle. Fish farmers have tried to use spiny dogfish waste with various degrees of success. In 1981 we began a test with both frozen and acidified feeds (2.5% M) based on spiny dogfish waste and compared it with a trawler fish mixture. The feeds were given to both salmon and rainbow trout. The growth was good for all feed types and no difference could be seen. There are several factors which need to be more closely studied with regard to the use of spiny dogfish waste. However, with regard to growth it appears that acidified feed from spiny dogfish waste can be used for salmon.

We have also used acidified blood and casein with success, for both salmon and rainbow trout (Austreng 1982).

Practical use

As mentioned, the soft feed used in the growth tests comprised only acidified feed and a binding agent in a 55/45 mix. One may also consider a mix of some acidified feed and some frozen feed in addition to the binding

agent. Such a mix was used for two years at the Research Station for Salmon at Averoy with good results. The mix comprised approximately 30% of frozen matter, 30% acidified feed from fish waste and 40% meal. This feed was of good consistency, was easy to handle and was well received by the fish. The quality of the fish appeared good. For those fish breeders who intend to use acidified feed, this mixture may be appropriate. It has the advantage of being a cautious first step. In the same vein, some experience is important before beginning to provide only acidified feed to the fish. For instance, it is easier to evaluate any necessary equipment investments.

Our experience with 30% acid feed in the mix was so positive that we later changed to a mix of acidified feed and a binding agent (meal) only, as the main feed at the Research Station for Salmon. This change was well received by those who work at the Station, and the fish grew better than previously. There may be many explanations for this. It is doubtful that it is the feed itself which is the cause of better growth; however, it is quite likely that the easier handling of the feed makes it easier for the workers to do a good job.

Additional information regarding the use of acidified feed is provided by Aasgaard (1980, 1981).

Summary

The least addition of organic acids which provided satisfactory preservation was 2.2% M, 2.2% P and 1.1% M + 1.1% P. If sulphuric acid is used, one can expect to use 2.5% S together with a little formic acid, propionic acid or acetic acid.

Feed mixtures with propionic acid apparently are rejected by salmon and therefore seem inappropriate. All other mixtures were well received by the

rainbow trout. Feed with formic acid as well sulphuric acid + formic acid have also provided good results with salmon. There are no indications that acidified feed negatively affects the health of the fish.

Successful tests have been carried out with regard to both salmon and rainbow trout with acidified feed from fish waste, feed fish mixtures, blood and casein. This method of preservation should be further pursued.

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